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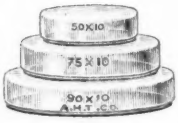

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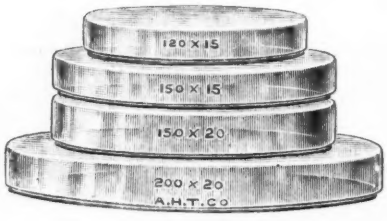

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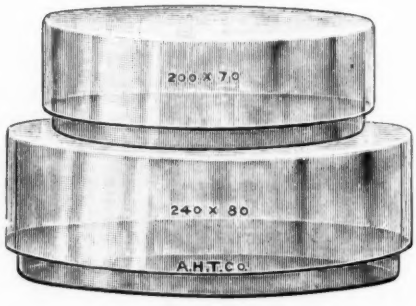

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THE GROWTH OF THE POTATO SCAB ORGANISM AT VARIOUS HYDROGEN ION CONCENTRATIONS AS RELATED TO THE COMPARATIVE FREEDOM OF ACID SOILS FROM THE POTATO SCAB

L. J. GILLESPIE

It is common experience that an acid soil may yield Irish potatoes (*Solanum tuberosum*) which are free from the common scab (actinomycosis), but that such a soil will produce scabby potatoes sooner or later if the acidity is neutralized by application of lime. When different soils are compared, it is also found that the scab is more likely to occur on neutral or slightly alkaline soils than on acid soils. Much information bearing on this matter was collected by Lutman and Cunningham (8), who studied the micro-organism[1] which causes the scab, and who finally state that, "The most hopeful method of attack on the organism in the soil is to change the neutrality or slight alkalinity of the latter to a weak acidity."

At the time this conclusion was drawn the existence of truly acid soils was doubted. Since then the occurrence of truly acid soils has been demonstrated by the writer (6) by the use of the hydrogen electrode and suitable indicators and has been confirmed by Sharp and Hoagland (12). A study of some soils of Northern Maine of the types Caribou and Washburn loam, by Hurst and the writer (7), in connection with a coöperative study between the U. S. Department of Agriculture and the Maine Agricultural Experiment Station, has brought out two points bearing on the potato scab question.[2] First, the Caribou loam, which is usually free from the scab, was found to be more intensely acid than the Washburn loam, which is very subject to scab. Second, the samples of Washburn loam

[1] First found by Thaxter (13, 14) and named by him *Oospora scabies* (15), and identified with *Actinomyces chromogenus* by Lutman and Cunningham.

[2] Throughout this paper, the common (corky) scab or actinomycosis is under discussion and not the powdery scab caused by *Spongospora subterranea*.

examined were neither neutral nor slightly alkaline, but were slightly or considerably acid, and it is known that some of these individual acid Washburn soils have yielded badly scabbed potatoes, though this was not explicitly stated. This work, therefore, confirmed the general proposition, that acidity of soils is antagonistic to scab, but showed that a feeble degree of acidity may not be sufficient to inhibit it.

Münter (10) reported that strains of *Actinomyces chromogenus*, not studied in their relation to potato scab, were very susceptible to acid; the experiments do not give, however, a useful indication of the degree of susceptibility, since the hydrogen ion concentrations were not ascertained, and cannot be calculated from the data given.

Shapovalov (11) reported that the organism, isolated from scabby potatoes, showed involution forms in a culture medium containing potassium phosphate; these involution forms were not observed in a similar medium without the potassium phosphate, and their occurrence may have been due to an increased acidity, as the phosphate used was monopotassium dihydrogen phosphate.[3]

The results of much work on the effect of acidity on the growth of micro-organisms have shown that the *intensity* of acidity, which is measured by the hydrogen ion concentration, is the important factor and that the *quantity* of acid, which is measured by titration, is of secondary importance. An extensive treatment of this subject has been given recently by Clark and Lubs (3).

It is evident that if the organism of potato scab is to be successfully attacked in the soil it is very desirable to know what intensity of acidity the organism can withstand. The object of the experiments described here was to determine what intensity of acidity is inimical to *Actinomyces chromogenus* in culture media.

STRAINS EXAMINED

The cultures were very kindly furnished by Mr. Michael Shapovalov, of Cotton and Truck Disease Investigations, U. S. Department of Agriculture. He states that strains II to IX, inclusive, and Act. S had produced scab on potatoes in his greenhouse experiments; Act. IX had been isolated about six months previously, and the others three to four years ago. These cultures produced the characteristic tough, leathery growth accompanied by a dark colored diffusible pigment and the characteristic "earth odor." Act. 1 to 5 (Arabic numerals) were found by him non-patho-

[3] Personal communication.

genic. These cultures did not produce the dark diffusible pigment and the growth was generally less leathery; the odor was somewhat similar to that of the others, but sometimes more berry-like.

In making inoculations it was seldom necessary to break up the leathery mass in the way described by Lutman and Cunningham, as all the cultures formed more or less of the easily detachable growth of "aerial filaments" when grown on potato agar. As it was hardly possible to inoculate a series of tubes with the same uniformity which is possible with micro-organisms which grow diffusely in a fluid medium, especial care was taken that the more acid tubes in every series were favored with larger amounts of inoculum. With few exceptions, the growth developed in a regular manner, showing that the inoculations were sufficiently uniform. Two other pathogenic strains, Act. I and II, were received from Mr. Shapovalov; these strains refused to grow on the citrate medium, and were not further studied.

CULTURE MEDIA AND ADJUSTMENT OF HYDROGEN ION CONCENTRATION

In the case of micro-organisms which have pronounced acid-forming powers, a convenient experimental method is to allow the cultures to produce acid until growth is thereby stopped, and then to measure the resulting hydrogen ion concentration. In the present case, however, the culture media were prepared with various hydrogen ion concentrations, and the growth of the organisms compared at the various degrees of acidity. In order to prepare culture media of stable hydrogen ion concentration it is necessary to provide for a large enough "buffer action." Otherwise, the media will not have the same hydrogen ion concentration when made up at different times from the same formula (even when synthetic media are used, unless all quantities are measured with extreme precision), and the reaction will change excessively on sterilization, or standing in glass, and possibly from other causes. For the region of hydrogen ion concentration which proved of interest, citric, succinic, or tartaric acid was used. To reinforce the buffer action, so as to be also effective near the neutral point, potassium phosphate was also added. Tartaric acid is less suitable than the other two acids for media containing potassium salts because of the slight solubility of acid potassium tartrate.

The reaction was adjusted finally by adding sodium hydroxide solution to the acid media. After the acid nutrient fluid was prepared in double the final strength desired, 10 cc. portions of it were treated with increasing quantities of standard (0.2 normal) sodium hydroxide solution, the total volume made up in all cases to 20 cc. with distilled water, and the hydro-

gen ion exponents determined with the hydrogen electrode.[4] When the exponent is plotted on coördinate paper as a function of the quantity of sodium hydroxide solution used, the resulting curve is called a titration curve, and the slope of the curve expresses the buffer action. The titration curves for the three media employed are shown in figure 1. It will be seen that the buffer action, i.e., the quantity of alkali required to produce a given change of hydrogen ion exponent, is greatest for the citrate medium, somewhat less for the succinate medium, and considerably less for the potato-tartrate medium, especially at the less acid exponents. When the media were sterilized the changes of reaction were smallest for the citrate medium, slightly larger for the succinate medium, and still larger for the potato-tartrate medium, although not excessively large in any case. The changes on sterilization are shown in table 1. These changes of the citrate and potato-tartrate media were studied at the time these media were made in quantity for the experiments on growth; the changes of the succinate medium were studied as a separate experiment.

TABLE 1

Changes of hydrogen ion exponent on sterilization

CITRATE MEDIUM			SUCCINATE MEDIUM			POTATO-TARTRATE MEDIUM		
Before	After	Change	Before	After	Change	Before	After	Change
4.77	4.75	−0.02	4.07	4.08	0.01	4.75	4.80	0.05
5.08	5.09	0.01	4.75	4.77	0.02	5.10	5.25	0.15
5.38	5.40	0.02	5.37	5.40	0.03	5.42	5.52	0.10
5.66	5.66	0.00	6.13	6.17	0.04	5.70	5.85	0.15
5.95	5.93	−0.02	6.93	6.98	0.05	6.04	6.10	0.06
6.94	6.97	0.03	7.44	7.35	−0.09	7.21	7.17	−0.04

The hydrogen ion exponents were determined by the use of the Clark electrode vessel (1), provided with the three-way stop-cock suggested by Cullen, a saturated potassium chloride calomel electrode (9), and an accurate and well installed potentiometer system. The measurements were made in a constant temperature compartment at 30°C. The calomel electrode was a well seasoned one which had been frequently tested with Michaelis' standard acetate solution and with Clark and Lubs' buffer mixtures (2). The apparatus was capable of measuring hydrogen electrode potentials with greater precision than was required by this work. It

[4] Following the general custom, the hydrogen ion *exponent*, the pH of Sörensen, is reported, rather than the *concentration* itself. The exponent is 7 for neutrality, is greater than 7 for alkalinity, and less for acidity. The most intensely acid soil, exclusive of acid mucks, yet reported had the exponent 3.7; the most alkaline had the exponent 9.7, (12).

was unnecessary to apply corrections for diffusion potentials or for barometric pressure. The platinum electrode was freshly coated for each day's measurements with palladium black after complete removal of the previous coating by means of concentrated nitric acid or anodic polarization, and, in the usual way, washed, treated with hydrogen by cathodic polari-

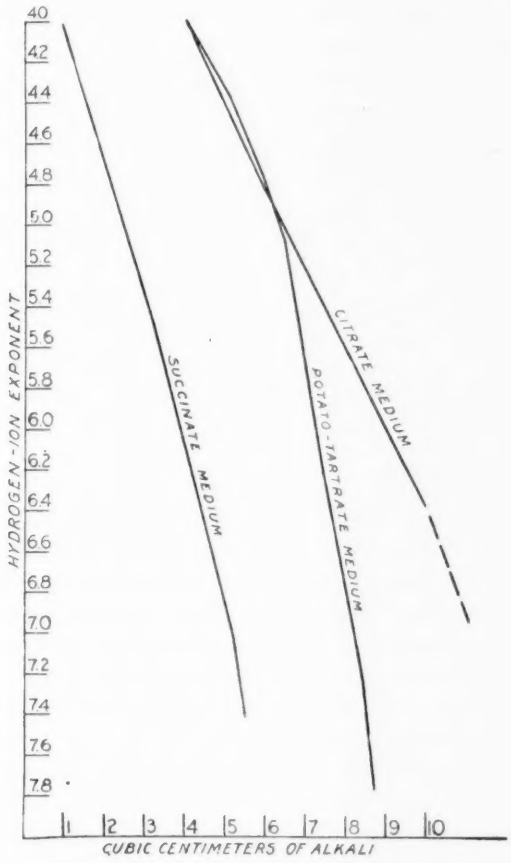

FIG. 1. TITRATION CURVES FOR THE THREE KINDS OF CULTURE MEDIUM

Showing the change of hydrogen ion exponent due to the addition of 0.2 normal sodium hydroxide solution.

zation in dilute sulphuric acid, and again thoroughly washed with distilled water. The electrode vessel was completely filled with hydro en, after filling with water, if necessary, then the fluid was admitted and the vessel shaken mechanically for five minutes. The shaking was stopped,

with the electrode totally immersed, the liquid contact made in a wide tube with the saturated potassium chloride solution, and the potential measured. The fluids offered no difficulties to precise electrometric determination.

For the cultural tests the media were made up in sufficient quantity and distributed into test-tubes. The test-tubes were of good quality, were not etched, and for all experiments were soaked a few hours in dilute hydrochloric acid and thoroughly washed with tap-water and then with distilled water before use. After sterilization, the hydrogen ion exponent was determined in a sample tube. Since the changes on sterilization were not excessive this procedure was safe, and it was not necessary to test the hydrogen ion exponent of the fluid in each individual test-tube after aseptic withdrawal of a sample.

The citrate medium contained when adjusted and made up to constant volume the following, in percentages:

Glycerol	0.66
NH_4Cl	0.04
KH_2PO_4	0.27
Citric acid	0.60
$MgSO_4.7H_2O$	0.002
$CaSO_4$	0.002
NaOH and distilled water	Varying quantities

Before addition of any alkali, 10 cc. of the double strength acid solution required 12.5 cc. of 0.2 normal sodium hydroxide solution for neutralization, when rapidly titrated in the cold in the presence of phenolphthalein.

The succinate medium contained the same proportions of the first three ingredients, but 0.24 per cent succinic acid instead of citric acid, and less magnesium and calcium sulphates, since the quantity used above did not dissolve completely in the double strength acid solution and the excess was separated by decantation.

The potato-tartrate medium was prepared as follows: 500 grams of clean sliced potatoes were boiled one-half hour with one liter of tap-water. The mixture was made up to its original weight and strained. 1.2 per cent tartaric acid was added. The mixture was filtered through cotton and 0.4 per cent of monopotassium dihydrogen phosphate was added. On standing in the ice-box over night the mixture deposited crystals of potassium acid tartrate; some of these were discarded and the rest redissolved by warming. Ten cubic centimeters of the solution required 9 cc. of 0.2 normal NaOH for neutralization. The titration curve was determined, sodium hydroxide was added to portions and the volume made up with distilled water to double the volume of the original solution and the adjusted portions tubed and sterilized. On sterilization a flocculent pre-

cipitate was formed in the 7.2 exponent tubes. The other tubes showed only a slight precipitate, equal in amount at the various exponents.

In all cases the media were autoclaved at about 15 pounds for fifteen minutes, and the differently adjusted portions of each kind of medium (citrate, succinate, or potato-tartrate) were sterilized at the same time.

GROWTH ON THE CITRATE MEDIUM

The cultures were incubated at 30°C. The results of the observations after 7, 14, 21 days are given in table 2. Strains 4, VII, and VIII were not observed in 48 days, the others showed no significant changes from 21 to 48 days. The extent of growth in the following tables is given by figures. Zero, 0, indicates no growth; 1, fair growth; 2, better growth; 3, very heavy growth. A ? indicates that growth was doubtful, or else was feeble.

TABLE 2

Growth of Actinomyces chromogenus on the synthetic citrate medium at various hydrogen ion exponents

	7 DAYS						14 DAYS						21 DAYS					
EXPONENT.....	4.8	5.1	5.4	5.7	5.9	7.0	4.8	5.1	5.4	5.7	5.9	7.0	4.8	5.1	5.4	5.7	5.9	7.0
Act. 1.....	0	0	0	0	0	1	0	0	0	0	?	2	0	0	0	?	1	2
Act. 2.....	0	0	0	0	0	1	0	0	0	1	1	2	0	0	0	1	1	2
Act. 3.....	0	0	0	0	0	1	0	0	0	0	?	1	0	0	0	0	?	1
Act. 4.....	0	0	0	0	?	1	0	0	0	0	1	2	0	0	0	?	1	2
Act. 5.....	0	0	0	0	1	2	0	0	0	1	1	2	0	0	0	1	2	2
Act. III.....	0	0	0	0	0	1	0	1	1	0	1	1	0	1	1	1	1	2
Act. IV.....	0	0	1	1	1	1	0	1	1	1	1	2	0	1	1	1	2	2
Act. V.....	0	0	1	1	1	1	0	?	1	1	1	1	0	?	1	1	1	2
Act. VI.....	0	0	0	0	1	1	0	0	0	1	1	1	0	0	?	1	1	1
Act. VII.....	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	1
Act. VIII.....	0	0	?	?	?	1	0	0	?	?	?	1						
Act. IX.....	0	0	0	0	?	1	0	0	?	0	?	1	0	?	1	?	1	1
Act. S.....	0	0	0	0	0	0	0	0	0	0	0	1	0	0	?	?	?	1

It will be observed that the different strains showed different resistances to acidity; this may not be significant, however, since the relations were not the same on the other media. All the strains were subject to a restraining influence of acidity at the exponent 5.1 or even at less acid exponents. None grew at all at 4.8. Surface growths were rarely seen.

GROWTH ON THE SUCCINATE MEDIUM

The cultures were incubated at 30°C. Surface growth was common and was always accompanied by aerial filament development. The

growth was in general better than on the citrate medium. The results of the observations after 7 and 14 days are given in table 3. Later observations showed no further changes.

TABLE 3

Growth of Actinomyces chromogenus on the synthetic succinate medium at various hydrogen ion exponents

	7 DAYS						14 DAYS					
EXPONENT.....	4.7	5.1	5.5	5.9	6.2	7.0	4.7	5.1	5.5	5.9	6.2	7.0
Act. 3.....	0	0	0	0	1	1	0	0	0	?	2	2
Act. III.....	0	0	1	2	2	2	0	?	1	2	2	2
Act. IV.....	0	0	1	1	2	2	0	0	1	2	2	2
Act. V.....	0	0	?	1	1	2	0	0	1	2	2	2
Act. VII.....	0	0	1	?	1	?	0	0	1	?	1	1
Act. VIII.....	0	0	1	1	2	2	0	0	1	2	2	2
Act. S.....	0	?	1	2	2	2	0	?	2	2	2	2

All seven strains were subject to a retarding influence at the exponent 5.1, and six strains at the exponent 5.5. At 5.1 only two showed any growth in 14 days and this was feeble. In the case of Act. S an extremely small surface colony was visible after 3 days in the 5.1 tube, and microscopic examination showed swollen mycelia and gonidia like the involution forms described by Shapovalov, which could not be found in preparations from the less acid tubes.

GROWTH ON THE POTATO-TARTRATE MEDIUM

Growth on this medium was much more rapid and vigorous. Surface growth, accompanied by aerial filament development, was shown by every culture except Act. 1. In table 4 the results are shown for some of the cultures, which were grown at 30°C., after 2, 7, and 21 days, and for four others, which were grown at room temperature, after 9, 19, and 46 days.

The pathogenic strains developed a dark color in the fluid when growth took place. The coloration was not so striking as on potato agar slants. Some of the non-pathogenic strains showed a dark rim under the surface growth; the coloration was sharply defined and did not diffuse in to the liquid below; the mycelium above was white.

All the strains examined grew more slowly at the exponent 5.2 than at the exponents 5.8 or 6.1, and with some strains the retarding influence of the acidity of the 5.5 tubes was apparent. It will be also observed that the growths in the 7.2 tubes were also slower and less vigorous than in the 6.1 tubes. This may possibly be attributable to the fact that a precipitate was formed in the 7.2 tubes on sterilization; or there may have

TABLE 4

Growth of Actinomyces chromogenus on potato-tartrate medium at various hydrogen ion exponents

	2 DAYS						7 DAYS						21 DAYS					
EXPONENT.....	4.8	5.2	5.5	5.8	6.1	7.2	4.8	5.2	5.5	5.8	6.1	7.2	4.8	5.2	5.5	5.8	6.1	7.2
Act. 2.....	0	0	1	2	2	1	0	1	2	3	3	2	0	2	3	3	3	2
Act. 3.....	0	?	1	2	2	2	0	1	2	2	2	2	0	2	3	3	3	2
Act. 4.....	0	0	1	2	2	2	0	2	2	2	2	2	0	3	3	3	3	2
Act. 5.....	0	1	2	2	2	2	0	2	2	2	2	2	1	3	3	3	3	3
Act. III.....	0	?	1	2	2	1	0	1	3	3	3	1	2	2	3	3	3	2
Act. IX.....	?	?	2	2	2	1	1	1	3	3	3	1	2	2	3	3	3	1
	9 DAYS						19 DAYS						46 DAYS					
Act. 1.....	0	?	1	1	1	1	0	1	2	2	2	2	0	1	2	2	2	2
Act. VII.....	0	0	1	2	2	1	0	?	1	2	2	1	0	1	2	3	3	2
Act. VIII.....	0	?	1	1	2	1	0	2	3	3	3	2	0	2	3	3	3	2
Act. S.....	0	1	1	1	2	2	0	2	2	3	2	2	0	3	3	3	3	3

been an inhibition due to the alkaline reaction which was found to develop in these tubes. A tube sterilized at 4.8 was adjusted to about 6 by adding a few drops of sodium hydroxide solution. When inoculated, it furnished a good growth, showing that sterilization in acid solution did not affect seriously the nutrient value.

A striking fact is that good growths finally occurred in most cases in the 5.2 tubes and in two cases in the 4.8 tubes. This might be taken to indicate that the organism can withstand higher hydrogen ion concentrations (represented by lower exponents) when the nutritive value of the culture medium is high, as it certainly is in the potato medium. This, however, is by no means certain from these experiments. As will be shown below, the reaction was steadily changing during the growth of the cultures, becoming far less acid than the initial reactions, and that this was a factor in permitting growths in the 4.8 and 5.2 tubes is strongly suggested by the following observations. When growths in the 4.8 tubes occurred, they started around the rim of the tube, and grew slowly toward the center, and in no case did the culture extend over the whole of the surface, even when heaped up in a thick mass around the rim. In four cases the same sort of growth was observed to take place at the exponent 5.2. At more favorable reactions the growths quickly covered the entire surface with a thick coherent matt. In two cases where no growth occurred in the fluid at 4.8 a deposit on the tube about 1 or 2 mm. above the level of the liquid was seen with a low power microscope to be an interlaced mycelium. Aside from the fact that the growths were slower at 4.8 and 5.2, these observations themselves suggest that the conditions were unfavorable. Or-

ganisms attached to the rim of the tube, or in the relatively undisturbed surface which curves up at the rim, may be able gradually to modify to their advantage the reaction of the fluid in their neighborhood, whereas in other parts of the medium the organisms float about, and the changes they make in the environment are obliterated by diffusion. A somewhat similar mechanical explanation was given by the writer to account for the fact that far smaller numbers of freshly isolated pneumococci are required to set up growth in solid medium, or on filter paper partly immersed in broth, than in broth (5), and essentially the same explanation has recently been given by others (4) to account for the growth of anaerobes under apparently aerobic conditions in the presence of inert porous substances. That such a phenomenon was not observed with the other two media, and that the organisms seemed somewhat less resistant to acidity on the other two media, may be due in part to the fact shown above that the buffer action was greater for the other two media, especially about the critical zone of hydrogen ion concentration.

CHANGES IN THE HYDROGEN ION EXPONENT DURING GROWTH

A number of the cultures were examined electrometrically after the observations on growth were concluded, in order to measure the changes in hydrogen ion exponent. The results are summarized in table 5.

The changes of reaction are in general largest for the potato-tartrate medium, less for the succinate and least for the citrate. All considerable changes of reaction were in a decrease of acidity (increase of exponent), which would tend to make the conditions more favorable to growth in the case of the initially more acid media.

MEANING OF THE RESULTS

The potato scab organism is inhibited in culture media at an acidity represented by the hydrogen ion exponent 5.2. Previous work has shown that cultivated soils of the Caribou loam, which is generally immune from the scab, yield water extracts which show, with methyl red as indicator, exponents from 4.9 to 5.5, the mean being 5.2 for those examined.[5] It would appear therefore that the acidity of the Caribou loam is often sufficiently intense to exert a restraining influence on the organism in the soil.

[5] Further study by Hurst and the writer, using the electrometric method, has shown that the soil extract from the typical Caribou loam has a hydrogen ion exponent close to 4.9. This work, including a detailed study of the correlation between the occurrence of the scab and hydrogen ion concentration of the soil, is being prepared for publication elsewhere.

TABLE 5

Changes in the hydrogen ion exponent during growth

Changes in the citrate medium in 37 and 48 days

	37 DAYS				48 DAYS												
Strain	2	2	4	4	1	1	1	5	5	III	III	IV	IV	VI	VI	VI	IX	IX
Growth	poor	good	fair	good	none	poor	fair	good	good	poor	fair	fair	fair	none	poor	poor	fair	fair
Initial exponent	5.93	6.97	5.93	6.97	4.77	5.66	6.97	5.66	5.93	5.40	6.97	5.09	6.97	5.40	5.66	6.97	5.40	6.97
Final exponent	5.93	6.68	5.85	6.50	4.77	5.68	7.46	6.14	7.62	5.40	7.14	5.16	8.42	5.36	5.70	6.93	5.49	7.14
Change in exponent	0.00	−0.29	−0.08	−0.47	0.00	0.02	0.51	0.48	1.69	0.00	0.17	0.07	1.45	−0.04	0.04	−0.04	0.09	0.17

Changes in the succinate medium in 36 days

Strain	1	1	1	3	III	IV	IV	V	S	S	S
Growth	none	poor	poor	very good	good	good	fair	fair	good	good	good
Initial exponent	4.70	5.50	6.25	6.25	5.86	5.50	5.86	5.50	5.50	5.86	7.45
Final exponent	4.70	5.88	6.41	8.07	6.90	6.98	6.90	5.59	6.85	7.80	8.48
Change of exponent	0.00	0.38	0.16	1.82	1.16	1.48	1.04	0.09	1.35	1.94	1.03

Changes in the potato-tartrate medium in 24 days

Strain	2	2	3	3	3	4	4	5	5	III	III	IX	IX	IX	IX
Growth	good	good	none	good	good	very good	good	fair	very good	good	good	good	very good	very good	fair
Initial exponent	5.25	7.17	4.80	5.25	7.17	5.25	7.17	4.80	7.17	4.80	7.17	4.80	5.52	6.10	7.17
Final exponent	7.18	8.72	4.83	7.18	8.62	7.53	8.92	6.47	8.92	6.36	8.50	6.76	7.84	8.05	8.68
Change in exponent	1.93	1.55	0.03	1.93	1.45	2.28	1.75	1.67	1.75	1.56	1.33	1.96	2.32	1.95	1.51

SUMMARY

A study was made of the viability of a number of strains of *Actinomyces chromogenus* in culture media adjusted to various hydrogen ion exponents. Two synthetic media and a medium prepared from potato extract were used, and especial attention was paid to the buffer action of the culture media, in order to locate the limiting hydrogen ion exponent with sufficient exactness. In media at the exponent 5.2 the growth was slower and generally less vigorous than at less acid exponents. Under some conditions individual strains were somewhat more sensitive to acidity, but the differences did not lead to any consistent distinctions among the strains. Sometimes the strains succeeded in growing well in a medium which had initially an exponent of 5.2 or even 4.8, but the growth was accompanied by a marked decrease of acidity, and the manner of growth gave reason to doubt whether even in these cases more than a poor growth can occur at such exponents.

It would appear that the acidity of the Caribou loam, which is known to be generally immune from actinomycosis, or common scab, of the potato, is often of sufficient intensity to exert in the soil an injurious action on the causal organism.

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LIGHTNING INJURY TO HERBACEOUS PLANTS

L. R. Jones and W. W. Gilbert

Certain sections of America are especially subject to severe midsummer electrical storms. Evidence that the lightning strokes accompanying such storms might be the cause of injuries to crops not commonly so diagnosed led us two years ago[1] to join in recording the nature of such injuries to two crops, potatoes and cotton, and to review the European publications.

Following this, similar occurrences have been recorded by different observers for onion,[2] kale,[3] and sugar cane.[4] During the past summer further evidence having come to hand through correspondence and personal observation, it seemed expedient to propose assembling such items for joint presentation on the program of the American Phytopathological Society[5] and later for coordinated publication. To this end a circular letter was addressed to the members of the Society which brought out an interesting series of replies dealing with a variety of observations. Naturally these present various degrees of accuracy as to details; and many of them have value only as supported by the more specific evidence of others. Where these concern woody plants it has seemed preferable to have them appear as separate articles whereas with the assistance of the various contributors we have correlated those dealing with herbaceous plants, treating each crop by itself.

POTATO

Further evidence has been secured each year since our earlier publication[1] that the description as there given of lightning injury is typical and that similar damage occurs frequently in Wisconsin and the adjacent states of the northern Mississippi Valley.

C. R. Orton reports from Pennsylvania that in 1915 two cases of lightning injury to potatoes came to his attention. One of these occurred at Dayton, July 21, and was reported to him by Mr. William Lawson, July

[1] Jones, L. R., and Gilbert, W. W. Lightning injury to potato and cotton plants. Phytopath. **5**: 94. 1915.

[2] Munn, M. T. Lightning injury to onions. Phytopath. **5**: 197. 1915.

[3] Jones, L. R. Lightning injury to kale. Phytopath. **7**: 140. 1917.

[4] Stevenson, John A. Lightning injury to sugar cane. Phytopath. **7**: 317. 1917.

[5] Lightning injury to crops (Abstract) Phytopath. **8**: 80. 1918.

26, in a letter from which he quotes, "My potato field looks fine with the exception of a patch about one rod across. There was an electric storm last Tuesday night and I noticed this spot first on Wednesday morning, when it looked as if the plants had been rolled during the night. The remainder of the field is standing and looking fine. However, I marked this patch carefully and have since found some other plants wilting but none over 10 feet from the original spot. The potato stalks bend, usually at the surface of the ground but sometimes along the stem, so that the plants droop or lie upon the ground. At the bend the stem turns brown, seeming in some cases to decay. This brown discoloration works along the stem while the leaves and shoots remain green. Indeed the stem seems dead but not dry." Plants were submitted to Orton by Lawson which showed the condition described and in addition there was some splitting of the stalks which he did not mention. Orton states that he saw another case in a potato field at Bethayres, Pa., August 25, 1915. At this time not a plant was alive within the affected area. The owner of the field stated to him that about the middle of July on the morning following a severe electrical storm, he observed the plants lying on the ground over an area about 20 rods lengthwise with the rows and averaging 2 rods wide. This strip occupied the lowest part of his field and some water was standing on it the morning the injury was noticed. At one end of this area stood a large white oak tree. Evidently the oak was struck by lightning, since the bark was peeled for several feet, and from the base of the tree the effects of the lightning seem to have spread over the wet area killing all the plants where the water stood. Orton adds that this is the largest area killed by lightning which he has ever seen, although he distinctly remembers from his boyhood experience on his father's farm in Vermont two cases of lightning injury in potatoes and one in corn. In both cases the areas were small, probably not over one rod in diameter and the plants were wilted and drooping when noticed a few hours later.

N. J. Giddings reports from West Virginia one case of potato field injury which he considers due to lightning. This was in the mountainous region about 12 miles from Morgantown. The county agent reported that the plants were dying in a circular area about the center of the field. Giddings visited the field soon afterward and talked with the owner. This man said that the day before the injury appeared there was a very severe thunder storm with much lightning, some of it very close at hand. The next morning he noted that a large number of potato plants were wilted in a spot near the middle of his field. This spot did not thereafter increase materially in size according to the owner and when Giddings visited it it was some 25 feet in diameter and approximately circular in outline.

Mel. T. Cook of New Jersey reports that he has received one complaint of lightning injury to potatoes this last summer which was typical in every way. He further states that for a number of years past New Jersey farmers have reported to him cases of injury to potato plants which they attributed to lightning. He adds, "I was at first inclined to believe the dying of these plants due to other causes but with the accumulation of evidence (and before your first paper came out) I became convinced that such injuries due to lightning are quite common in New Jersey. The area of injured plants is in general approximately circular and from 20 to 50 feet in diameter. The plants in the center are usually killed outright, while those near the circumference may show evidence of life for several

FIG. 1. LIGHTNING-KILLED AREA ABOUT 20 FEET IN DIAMETER IN A MICHIGAN POTATO FIELD
Contributed by G. H. Coons

days. However, after a few days the line of demarcation between the injured and the healthy plants is distinctly evident."

G. H. Coons contributes data for Michigan as follows under date of August 16, 1917:

"I am sending a photograph (fig. 1) of a potato field hit by lightning, as I take it. This brings out the more or less circular area, about 20 feet in diameter, occupied by dead plants. A peculiar fact, not clearly shown in the photograph, was that the dying extended 4 to 6 feet beyond the general circle along two rows. The field showed a considerable degree of ridging and it seems probable that the distribution of water standing in the furrows between the rows may be a factor in determining the shape of the injured area. The plants showed a typical browning of the stems,

the discoloration extending up into the second and third whorls of leaves. This is the fourth case of lightning injury to which our attention has been called this summer by Michigan county agricultural agents. In one case the spot was exactly circular, about 48 feet across, with every plant killed. I saw only a few of these vines, since, when I visited the place one week after the injury, the farmer had removed most of them under the impression that the trouble was an infectious disease.

In another case from Alpena County the injury appeared suddenly in a spot in the field. Within four days the tops of plants on this spot appeared dead but were later reported as starting a new growth. I interpret this as lightning injury in which the bases of the stems were not entirely killed, but I am not sure how well this theory accords with the physics of lightning stroke."

E. S. Schultz reports that, in connection with his investigations of potato diseases in Maine, he visited the farm of Mr. F. J. Kiersted, Presque Isle, about July 15, 1917. In going over his potato field a spot about one rod in diameter was found where the vines were dead. Mr. Kiersted stated that a severe electrical storm occurred about July first during which lightning struck in that vicinity. A few days later he observed this spot with dead or wilting plants. When Mr. Schultz visited the field the potato plants in the center of the spot were dead and dry and those immediately surrounding the dead area were noticeably injured.

In Wisconsin cases of lightning struck potatoes have come to the attention of the senior author each year since our first note. These have, in all cases, occurred in either July or August, the months of severe electrical storms, and have conformed in general type to those previously described. In 1917 there were four such examples. Of these three were reported to us by J. W. Brann, who, as official state inspector of certified potato fields, with wide opportunities for observation, has become familiar with the various maladies affecting Wisconsin potatoes. Brann personally visited all of these fields, photographed them and secured evidence which indicated that in each case the injury was due to lightning. Two of the fields were perfectly flat, while in one the affected area was on a gentle slope. In two cases the soil was rather heavy, in one sandy. In size the smallest spot was 10 to 12 feet across and the other two were about 25 to 30 feet in diameter. All were roughly circular in outline, only one showing an exceptional feature. In this case, while the general outline of the area was circular, the plants in one row were all killed for some 24 feet beyond the general boundary line. This field was planted in drills with continuous ridging of the rows. It is significant that in this case, as with that cited by each Coons and Orton, when the range of injury extends beyond a circular area it tends to follow the direction of the rows.

It seems probable, as suggested by both of these other men, that this is associated with the presence of water in the furrows. Another Wisconsin case occurred in a small city garden near the phytopathological laboratory in Madison. A severe electrical storm occurred the night of July first. When the owner visited the garden the next morning he found the potato plants prostrate and wilting over an area about 10 by 15 feet. The senior writer visited the field later in the day and was fully convinced that it was due to lightning. No disturbance of the soil was apparent but the general symptoms were those previously noted, viz., killing of the main stems from slightly below the ground level upward for one-half to full length with resultant wilting and death of the leaves on the balance.

FIG. 2. LIGHTNING INJURY TO COTTON

Farm of A. B. Broadwater, Johnston, South Carolina. Photographed June 19, 1917, by R. C. Faulwetter.

COTTON

R. C. Faulwetter sends a photograph illustrating injury, in June, 1917, to a South Carolina cotton field attributed to lightning. He summarized the evidence justifying this conclusion as follows. "It was stated by both the owner of the farm and his tenant, a white man that lightning struck this spot or its immediate vicinity during a severe night storm and that early the next morning the cotton was noticed to be in a wilted condition. A day or two later the patch was entirely dead. I visited and photographed the place four or five days afterward" (fig. 2).

CAUTION

Since in the nature of the case much of the evidence relative to lightning injury to field crops must be circumstantial and indirect there is

evident need of caution in accepting it as conclusive. Two correspondents have especially urged this from their experience—F. C. Stewart with potato and F. H. Blodgett with cotton—and it seems appropriate to insert their warnings at this point.

Stewart writing of his observation in New York, says, "Lightning injury has frequently been described to me by farmers, but the few cases which I have been able to investigate have proved to be the work of something else, usually some fungous disease or insect pest." As Stewart has previously stated (Phytopathology **5**: 197. 1915) the general appearance of areas where he attributes the damage to the potato stalk borer, *Papaipema nitela*, are so similar to those described for lightning that they are liable to confusion. He concludes, "I do not doubt that spots in fields of potatoes and other crops are sometimes killed by lightning, but I am of the opinion that the great majority of cases reported by farmers are due to other causes."

Blodgett in correspondence contributes similar cautionary advice based on experience in quite another section and with different crops. He authorizes the following quotation. "In the absence of convincing evidence I should feel very hesitant to consider any phase of field injury to crops observed by me in Texas to be due to discharges of atmospheric electricity (lightning). Some of the fields through the stiffer black soil area of the state have rather isolated patches of dead cotton scattered through them, but these patches can be traced to natural causes rather than the improbable one of lightning discharges. The dead areas have, the last two seasons, been much larger than normal under the aggravated influence of drought conditions which has been accompanied by a marked absence of lightning or other violent atmospheric disturbances."

In a subsequent letter, Blodgett makes the following pertinent statements, which he authorizes us to publish, distinguishing between lightning injury spots in cotton fields and spots where cotton has been killed by Ozonium.

"The areas infested by the root fungus, *Ozonium omnivorum*, are called "alkali spots" by the average farmer in Texas, and when first noted in a new piece of land often are as small as a rod across, enlarging as the season advances, and as the field is used for repeated crops of cotton. Plants at the margins of such diseased areas show a wilted or half dead appearance, much as is described for lightning injury, but this is not a sudden phase, to be noted only after a thunder storm for example; and there are likely to be healthy stalks scattered through the affected area apparently untouched by the fungus injury. These two conditions clearly exclude these "alkali spots" from possible confusion with the lightning trouble under discussion."

TOBACCO

F. A. Wolf reports from North Carolina that a case of lightning injury to tobacco came under his observation this last summer (1917). The plants were destroyed in an area about 30 feet in diameter and about the margin of this area the plants were stunted. The cells of the pith cavity in these latter plants were largely destroyed.

E. G. Beinhart,[6] who has had opportunity for wide observation in American tobacco fields has made some highly interesting observations which he describes as follows:

"The contributor has observed eight cases of lightning injury to tobacco and understands that it is not a rare phenomenon in tobacco fields, especially in the Connecticut Valley, where severe electrical storms occur frequently during the growing season.

The first case observed occurred at Ames, Iowa, in a field of half-matured tobacco. The seven other cases occurred in the Connecticut Valley: three at Suffield, Conn., in September, 1907; August, 1914; August, 1916; one at Avon, Conn., in July, 1914 (reported by Clinton in Conn. Agric. Expt. Station Report, 1915. p. 448); one at Hatfield, Mass., in 1917. Two cases were on shaded tobacco fields: one in 1916 at East Windsor Hill, Conn., and the other in 1917 at Buckland, Conn.

The case in Iowa occurred in a patch of mixed varieties of tobacco some 60 by 120 feet in size, surrounded by experimental plots of grasses, legumes and cereals. The 1907 Suffield case occurred in a strip of Havana Seed perhaps 200 feet wide which projected between two farmsteads. It should be noted that part of the charge struck an electric service wire. The 1914 and 1915 Suffield flashes struck into an open field of Havana Seed a considerable distance from any building, wires, water, etc. It is interesting to note in this respect that these two flashes struck only 200 yards apart, the first in a low part of the field, the second on the side of a knoll. In 1914 at Avon the lightning struck in an open field of Havana Seed bare of any nearby improvements and perhaps 150 feet from a hedge of trees bordering a stream. At Hatfield it occurred in an open field of Havana Seed perhaps 200 feet from any building and less than 100 feet from the wire frame of a shaded field. The 1916 East Windsor flash struck near the edge of a shaded field of Cuban tobacco 100 feet from a tobacco barn. In 1917 at Buckland the edge of a shaded field of Cuban tobacco at a distance from any building was the scene of the damage.

The several fields were in different conditions of growth ranging in size

[6] Mr. Beinhart is Assistant in Tobacco Investigations, Bureau of Plant Industry, United States Department of Agriculture.

from plants 3 to 4 inches high to those approaching maturity. The effect is practically the same regardless of the size of the plant, and the areas affected were quite similar in all cases. In cases of complete shock the plant wilts and the stalk shrinks circumferentially, forming longitudinal folds and becoming blackened. The plant juices are forced to the surface, making a slimy covering which may later develop molds under certain conditions. The leaves likewise wilt and become blackened, especially near their bases. The appearance of a nearly full-grown plant an hour after the stroke is one of total collapse from which there is no recovery. The roots also are killed and assume a charred appearance, becoming soft.

The conditions observed in the fields of tobacco after the lightning struck were similar to those already described for other crops. A circular area 20 to 50 feet in diameter, more or less regular in outline, radiates from a central portion in which all the plants are killed. About this central portion and between it and the rest of the field where the plants are normal, different degrees of shock were found, some plants recovering sufficiently to harvest and others dying within seven to ten days after the stroke. The leaves on the partially shocked plants seldom increase in size and become wrinkled and twisted. They may assume a condition of permanent wilt without wholly ceasing to function. Some of the leaves appearing later on these plants approached normality.

Plants in this last condition usually develop hollow stems, the pith largely disappears and the vascular bundles are affected. A slime develops within the stalk. The cortex, particularly near the base of the plant, becomes brown or black in parts. As the plants retain life the slime disappears and the inside becomes dry and woody and assumes a light color. An occasional plant within the area may be to all appearance untouched and continue normally. In no case has the present contributor observed a rupture of the tissue of the leaf or stalk.

It appears that there may be a forking of the flash, as in one case there were two spots of dead and wilted plants separated by a strip of normal plants perhaps 50 feet wide. The grower reported having seen but one flash.

There was no difference in resistance to the electric charge by plants of different ages. The area affected in young fields approached in size and form those which occurred in older fields. The escape of a few plants within the area of intense shock occurred quite as frequently among young as among older plants.

In those cases prior to 1917 there was no noticeable effect upon the succeeding crops growing upon the areas which had previously been struck.

A most interesting fact in regard to lightning is found in shade-grown tobacco. The effects are similar but the plants in the two cases observed had been more or less destroyed immediately as a result of fire. In the culture of shade-grown tobacco a wire frame is supported on posts 9 feet above the field. Sheets of tobacco shade cloth, a heavy wide-mesh mosquito netting, are sewn to wires which are usually set every 33 feet in check.

The writer, among others, had wondered for several years concerning the protection from lightning afforded to a tobacco field by such a network of wires. The first case came under his observation in the summer of 1916 at East Windsor Hill, Conn., on Cuban tobacco 8 inches in height. Lightning struck near the edge of a 50-acre shaded field, perhaps three minutes before rain fell. It traveled to the ground through a post, splitting it and causing the death of the neighboring plants within a circular area 10 feet in diameter with a narrow zone of partially shocked plants extending around this area. At the moment of contact with the cloth, fire began and before it could be extinguished by the plantation labor the cloth over more than one acre had burned. No wires were broken or melted. It appeared to the observer that every wire carried part of the charge. Wires a quarter of a mile away vibrated for several moments under tremendous tension. Because of the fire practically every plant within the burned area was badly charred from falling embers of cloth or was destroyed by trampling. Sufficient evidence was found, however, to show that the plants within the zone of the flash were killed.

The second case of lightning striking shade-grown Cuban came to the contributor's notice in 1917. The tobacco was perhaps 20 inches high, and observation was made a few days after the flash. The lightning struck upon the outside wire of the frame and it behaved similarly to the East Windsor Hill case noted above. The cloth was set on fire and something over one acre was burned before the cloth could be cut in the line of fire or rain fell to check it. Because of the falling embers and trampling of many feet over the area affected, most of the evidence was destroyed although the damage was similar to the cases already noted.

It should be observed here that the area was semi-circular and of perhaps 6 to 8 feet radius, the flash passing through a post on the edge of the field, splitting it. Grass which covered the ground immediately adjoining the zone of tobacco was apparently unaffected.

The outstanding fact is the smaller size of the areas affected in the shaded fields. In the light of so little evidence as afforded by only two observations, it is not clear whether the wire affords protection to the crop beneath it. Perhaps the range of action was limited, since the presence of fires shows that no rain had fallen to wet the cloth, and the areas

affected were small because of the lack of conducting power of the normal soil.

From the pathological standpoint, in tobacco it is important to bear in mind the effects of lightning. As in other cases of injury from physical causes, as hail damage, the field appearance may be such as to arouse the interest of a pathologist, particularly within 7 to 10 days after the charge. The total collapse of certain plants, the partial wilting of others about them and the malformations, together with the blackened stalks and slimy interior of the stalks, particularly near the base, are facts sufficiently interesting upon the surface to interest an investigator and lead to erroneous conclusions concerning the presence of disease.

FIG. 3. CUCUMBER LIGHTNING INJURY SPOT IN A FIELD NEAR BIG RAPIDS, MICHIGAN

Photographed, August 29, 1917, by W. W. Gilbert

CUCUMBER

We have seen no other previous record of lightning injury to a cucurbitaceous crop, nor, indeed, to any prostrate vine. Hence especial interest attaches to such injury of cucumbers as observed by W. W. Gilbert and M. W. Gardner. The following account with the illustration is furnished by them.

During a rather extensive survey of cucumber fields in the vicinity of Big Rapids, Michigan, an unquestionable case of lightning injury was found on August 29, 1917, in the field of L. E. Weygandt. The lightning-struck area consisted of a central more or less circular portion about 30 feet in diameter within which every plant was killed, and a peripheral zone 6 to 10 feet broad in which the injury diminished more or less progressively from serious damage on the inside of the zone to little or no injury on the outside (fig. 3). No disturbance of the soil by the lightning

was noted at any place in this area. There had been a severe electrical storm August 24. The owners of the field first observed a wilting and dying of the vines in this area when they picked the cucumbers on the day following this storm. Examination of the dead and injured plants showed that no parasite was responsible for the phenomenon. The plants at the time of the injury were nearly full grown with runners 3 to 4 feet long. The vines in the central area had withered and dried rapidly without preliminary color change showing evidence of sudden death. In the marginal zone varying degrees of damage were apparent with indications that there was direct injury to leaves and runners as a result of the passage of the current. This was a localized injury evidenced by silvering of the lower epidermis of certain leaves and by brown discoloration and shrivelling of affected veins, petioles, and internodes. In the partially killed plants there was a marked browning and drying of certain internodes in the runners and occasionally of the petioles.

TOMATO AND CUCUMBER

Professor E. H. Toole, Botanical Department, Purdue University, reports an interesting case of what appears to have been lightning injury to cucumbers and tomatoes observed on the truck farm of W. S. Roebuck at Fort Wayne, Indiana, during the summer of 1917.

An area of dead plants was found at the junction of tomato and cucumber plots. A tomato stake about 6 feet from the edge of the plot was the center of a circular area of dead plants. In the tomato plot the diameter of the killed area was about 30 feet (paced), but the injury extended a noticeably shorter distance into the cucumber plot. The severity of the injury to affected plants was about equal in both cases.

The cause of the injury was first noted by a former cotton grower of the south who had noted many cases of similar injury in cotton fields.

SUMMARY

Summing up the recorded evidence, as cited in our previous article and in this paper, lightning injury has been reported for the following herbaceous crops. Potatoes, frequent and with like symptoms in Europe and America; several consistent reports for each tobacco, cotton, and sugar beets; single reports for each kale, alfalfa, ginseng, onion, tomato, cucumber, (2 reports) Indian corn, and sugar cane. It should be noted, however, that the evidence relative to the latter two crops is less direct and explicit than with most of the others.

As previously explained (Phytopathology **7**: 142, 1917) special attention should be given to further evidence regarding injury to the legumes

which are grown in large acreage—viz., clovers and alfalfa, beans, peas, and to the Gramineae—cereals, Indian corn, canes, and grasses. Where plants of different species are growing in mixed plantation in the lightning struck area note should be taken of any variations in the kind or extent of the injuries.

In respect to description of the injuries, while there is some variation in details, there is a surprising amount of likeness as to the general characters. Certain things have been reported upon often enough to merit review. In general the killed areas vary from 10 to 30 feet in diameter and are roughly circular in outline. Where much larger areas or irregular extensions have been noted it has been suggested that the distribution of the damage was probably associated with the presence of surface water. As suggested in our earlier article it seems possible, and at least justifiable as a working theory, that the greatest damage results when the lightning stroke occurs soon after the rain begins. According to this theory the drier soil below the surface would then favor the wider diffusion of the shock through the recently wet or flooded surface layer. In general the killed areas are sharply delimited although the margins are somewhat ragged and there is a narrow zone of partially killed or weakened plants.

In most cases there is little or no evidence of mechanical disturbance of the surface of the soil although certain observers make definite report of a small crater-like depression at the center of the disturbed area. Probably this is not a constant feature and in any case the amount of dislocated soil is so small that the accompanying rain would generally obscure or obliterate the evidence. With herbaceous plants there seems little mechanical splitting or tearing of the injured tissues. It seems possible that in the few cases where this is reported (potato, sugar cane) it may represent a splitting due to the sharp bending and the shrinkage of the stems after the injury rather than an actual rending by the electrical discharge.

In general, therefore, the evidence seems to accord with the explanation of the phenomena offered at the close of our earlier contribution in this journal (**5**: 100, 1915).

In this it was pointed out that there is a fundamental difference in type between injuries to be expected with the lower herbaceous plants as compared with those having taller woody stems. In the latter the electrical exchange occurs through the stem of the single plant which often shows severe mechanical rupture. With the smaller herbaceous plants the exchange seems more diffuse occurring perhaps in part directly from the moist surface of the soil as well as from the aerial plant parts. We quote from the explanation which we formulated earlier as applicable to the injuries to potato and cotton and believe that the further evidence presented above tends to strengthen this hypothesis.

"When an electric storm breaks suddenly following a period of dry weather and the first rain wets the top soil, there remains a layer of dry earth between this wet surface and the moist soil underneath, which is a poor conductor of electricity. When the lightning strikes the wet surface soil, it disperses in all directions, horizontally and then downward into the earth, following lines of least resistance. The plant stems and roots with their abundant water content are better conductors than the layer of dry soil just mentioned and so the electrical current passes through them. The tissues may thus be variously injured or killed depending upon the amount of current passing through them. The strength of the current, of course, diminishes the farther it gets from the center of the affected spot, and consequently the lessened injury at the margins of the area. In some cases apparently the discharge may be broken and "strike" in several spots, near together."

The balance of the evidence still remains strongly in favor of the earlier conclusion that certain of the herbaceous crops suffer more regularly and seriously from lightning stroke than others, e.g., potatoes, sugar beets, and cotton as contrasted with the grains and grasses. The accumulation of further observational evidence is therefore worth while and the challenge remains for experimental confirmation of the theories.

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LIGHTNING INJURY TO CITRUS TREES IN FLORIDA

H. E. Stevens

Lightning injury is not uncommon in the Florida citrus groves and a small percent of the trees are probably more or less affected by this agency each season. The loss in this respect is usually small since few of the affected trees are completely destroyed, and the injury for the most part is confined to scattering twigs and branches over a number of trees.

This type of injury was first observed by the writer during the summer of 1915 and at the time was suspected of being parasitic in origin. Other cases were reported later in the year and a field study was made of several of these. It was plainly evident from this investigation that lightning was the primary cause of the injury. The injury was described and reported in the Annual Report of the Florida Agricultural Experiment Station for 1916, pp. 75–78R.

Within the past three years a number of such cases have been reported from different parts of the citrus belt indicating that lightning injury is of frequent occurrence and that it is not peculiar to any particular locality.

When lightning strikes in a grove, from a few trees to two or three dozen may show varying degrees of injury. Usually one or two trees in the affected area will be severely injured or perhaps killed, while on those adjacent or in the immediate vicinity the injury is confined to scattering twigs and branches. The area of struck trees is not always definitely circumscribed. The tree or trees receiving the full shock may occur at the center or near the edge of such area. In some cases trees adjacent to those severely injured are unaffected while trees beyond have injured twigs. Clusters of three or four shoots of the same age and condition of growth may have one or two shoots injured while the others are entirely normal. Splitting of the bark or laceration of the trunk is not observed but in severe cases a strip of dead bark can usually be traced down the trunk to the surface of the soil. In such cases an area of dead bark frequently encircles the trunk at or near the ground line.

APPEARANCE

The most striking feature of the injury is the characteristic spots or blotches produced on the surface of the young green shoots and twigs (fig. 1). In the first stages of development these are represented by pale

greenish-yellow to yellowish areas outlined on the surface of the bark, which may vary much in size and shape. In some cases the spots cover only a few square millimeters of surface and again specimens are observed where the entire surface of the twig is involved for a distance of 3 or 4 inches. The leaf and leaf petiole in such instances seem to escape injury. Spots are frequently found encircling the petiole and in specimens where

FIG. 1. CITRUS TWIGS INJURED BY LIGHTNING

the entire twig is girdled or invested, the green petioles and leaves stand out in marked contrast against the discolored areas.

In later stages the spots or blotches become yellowish-brown and they are raised above the healthy tissue. The surfaces are smooth for a time and covered by a thin glazed membrane which may become more or less bleached with age. The tissue beneath this covering is soft and spongy, being composed of a few layers of dead cells. In most cases the injured areas or spots seem to involve only a few layers of the surface cells, the

cambium being rarely affected. The deadened areas or spots are gradually elevated and eventually the surface membranes rupture, usually by longitudinal fissures. The surfaces then become ragged or lacerated and finally slough off leaving a brownish, roughened scar.

The first stage of the injury is due directly to lightning. At this time the spots or areas are not visibly depressed but the affected tissue appears dry and the cells somewhat collapsed. Tissue thus weakened offers a ready means for the entrance of fungi and bacteria which rapidly complete the destruction. A species of Colletotrichum, probably *C. gloeosporioides* is constantly found associated with the spots and blotches and no doubt this fungus has an important bearing on their later development. When a spot or blotch once forms there is apparently no tendency to increase in size or extend beyond its original limit. On older branches and limbs protected by an outer corky layer, such spots or blotches are rarely noted and only in one or two instances were blotches found on the leaves that could have been attributed to the same cause.

When the trunk is lightning struck the injury is usually represented by a narrow strip of dead bark, from one-half to two or more inches in width extending downward to the surface of the soil. At the base of the affected tree this strip may broaden into an area completely girdling the trunk. In this case the affected tissue is slightly sunken and the cells appear collapsed. The bark is killed down to the hardened wood. The dead bark is soon invaded by fungi and bacteria which cause a rapid decay. Trees affected in this manner rarely recover from the shock.

FLORIDA EXPERIMENT STATION

A NEW DISEASE OF THE IRISH POTATO

C. W. Carpenter

A disease of the Irish potato occurring in Hawaii appears to be new to pathologists, no record of a similar disease of this crop having been found in the literature. This disease was first observed in May, 1917, in the vicinity of Honolulu and Castner on the Island of Oahu. It was subsequently found to be prevalent and destructive in all of the potato sections of the Islands and is now recognized as a malady of considerable importance.

When there is a minimum of rainfall, whether the plants be irrigated or not, they are frequently seen to dry up and die from the growing tip downward. The small young leaves both terminal and axillary become bronzed upon the lower surface, twist and curl upon the longer axis, both leaves and shoots becoming abnormally hirsute and soon drying up and dying. Often the plants grow well until about the time of flowering before being affected. The yield of the diseased plants is naturally inconsequential.

Upon critical examination with a hand lens, the young growth is found to be infested with a myriad of mites, so small as to be scarcely visible with a magnification of less than twenty times. That these minute organisms are responsible for the disease seems evident. They are present in sufficient numbers on plants with the recognized symptoms to warrant this conclusion and the reaction of the plant is such as we have come to associate with mite injury. Furthermore if the mites be kept off a portion of the plants by spraying or dusting with sulphur those so protected develop normally while adjacent unprotected plants are devastated.

Tomato plants growing under similar climatic conditions are also attacked by mites and apparently of the same type. Whether this disease is of as much consequence as the potato disease is not determined.

A mite disease of the tomato is described as occurring in Florida by Rolfs (1) under the name Phytoptosis. The recorded symptoms are much the same as those observed in the potato mite disease in Hawaii. The potato apparently does not develop plant hairs so strikingly in response to the irritation of the mites as does the tomato in Florida. The mite associated with the potato disease in Hawaii is also quite different from the tomato mite in Florida, *Phytoptus calcladophthora* Nal. A mite dis-

ease of litchi, *Litchi chinensis*, caused by an undescribed species of Eriophyes (Phytoptus), is described as prevalent in Hawaii by Higgins (2). He has called this disease erinose of the litchi because of its similarity to the erinose of grape and other crops.

Until the opinion of a specialist can be obtained a generic name for the potato mite can hardly be hazarded. It may belong to the same group as the so-called red-spider (Tetranychidae). The mites are oval shaped, almost colorless when young, the adults becoming slightly brownish. The young mites are provided with three pairs of legs and the adults four pairs. Minute glistening white, papillate or sculptured bodies abundantly present upon affected leaves are believed to be the eggs of the parasite.

Whether this disease is serious under optimum conditions for the potato is doubted. With the average rainfall in our potato sections the mites do not appear to become established. But in drought years as in the summer of 1917, losses due in part at least to this pest are estimated at from 5 to 50 per cent or more, in our upland sections. In the vicinity of Honolulu and other sea level places where the temperature is rather high for this crop during the greater part of the year and where other factors influencing growth cannot be considered as favorable for the normal development of vigorous plants the mites appear to be the active factor in causing total loss.

Where the potato would be healthy except for the mites spraying with lime sulphur or dusting with dry sulphur has been found an effective means of control. For lowland plantings the suggestion is usually made that seed be planted in the fall or winter months so that the crop may mature before the dry season commences.

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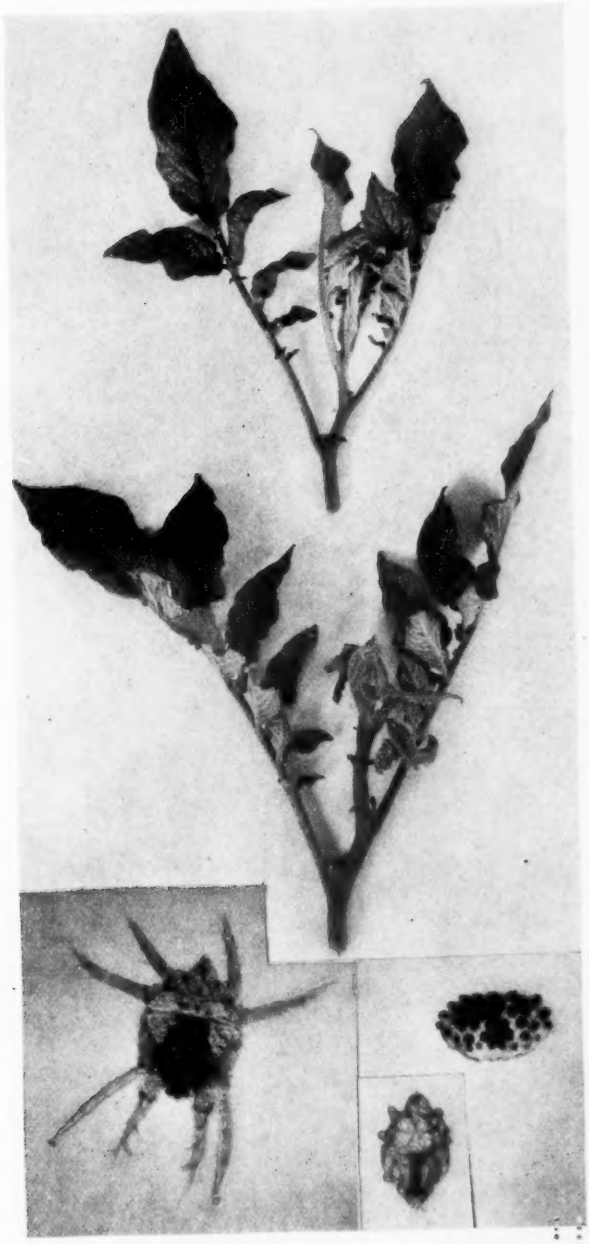
(1) ROLFS, P. H. The tomato and some of its diseases. Florida Exp. Sta. Bul. 21. p. 22–23, 1893. Also Bul. 47, Diseases of the tomato, p. 143.

(2) HIGGINS, J. E. The litchi in Hawaii. Hawaii Agr. Exper. Sta. Bul. 44, 1917. p. 17–18.

PLATE I

MITE DISEASE OF IRISH POTATO

Mite infested buds, shoots and leaves, showing characteristic appearance of injury. Adult mite, young mite and egg. × 160.



CARPENTER: MITE DISEASE OF IRISH POTATO

SOME FACTORS AFFECTING VIABILITY OF THE UREDINIOSPORES OF CRONARTIUM RIBICOLA

GEORGE H. DUFF

Of the problems presented by the White Pine Blister Rust, none are more difficult to solve and none have a more direct bearing on the methods which should be adopted for control, than those involved in the question of the greatest distance at which spores are effective, and in the question of the hibernation of the fungus on Ribes. Hoping to obtain some evidence on these problems, a series of experiments was begun in the latter part of August, 1917, in which the viability of the urediniospores of Cronartium, under various conditions, was made the subject of study. The following three points were kept particularly in view:

1. A possibility of the urediniospores passing the winter in a living condition on old leaves ready to cause infection of Ribes in spring.

2. A general study of the viability of the urediniospores, to determine their efficiency as infective agents.

3. A possible toxic action of sunlight upon these spores.

Evidence bearing on the question of over-wintering was sought by placing the spores in a specially-constructed refrigerator kept at temperatures between 2° and 5°C., from which spores were removed periodically for germination in hanging drops. When placed in the refrigerator two weeks after collection a negligible percentage of spores were germinable, but reduction in temperature stimulated them to greatly increased germination. By this means a continually decreasing percentage of spores were kept in a viable condition, until, after the lapse of a further period of about three weeks, the number that germinated readily was negligible once more. Before the end of four weeks the spores had ceased to germinate entirely. At the end of three weeks, subjection to sudden changes of temperature was effective to a slight degree in stimulating germination, but even this soon failed. From these results it would appear improbable that the urediniospores can over-winter a period of six months, even under the most favorable circumstances.

Experiments by McCubbin[1] of this Laboratory on the rate of fall of these spores show the great theoretical possibilities of wind dispersal

[1] McCubbin, W. A. Dispersal distance of urediniospores of Cronartium ribicola as indicated by their rate of fall in still air. Phytopathology **8**: 35–36. Ja. 1918.

under favorable conditions. The question naturally arises whether, at the end of a long journey in the air, especially in clear, hot weather, such spores would still retain sufficient vitality to cause infection. It was hoped that by testing the power of germination after various exposures to sunlight some evidence might be deduced on one side or the other of this question.

Experimentation showed that exposure to glass-filtered sunlight $2\frac{1}{2}$ to $5\frac{1}{2}$ hours at temperatures of 30° to 44°C., materially reduced the germination. When the temperature was kept below 20°C. however, exposure to glass-filtered sunlight had no inhibiting effect; on the contrary, the percentage of germinated spores was considerably greater upon exposure than in the check cells. Two repetitions of this experiment both yielded the same result. It would seem a safe conclusion then that exposure to glass-filtered sunlight alone for a few hours has no toxic effects on the urediniospores and that the high temperatures probably caused reduction in germination in the first experiments.

These results led to a suspicion that the fact that ultra-violet rays are absorbed by glass, might account for the apparently innocuous character of glass-filtered sunlight. Experiments were therefore undertaken in which the spores were exposed directly to a beam of light from an electric arc, which is rich in ultra-violet rays, and then tested for powers of germination. To summarize the more interesting results, it was found that exposure for one hour, or for forty-five minutes, at a distance of 16 inches from the arc, with the temperature below 20°C., completely inhibited germination. This would seem to indicate that any toxic effect sunlight might have upon the urediniospores, would be due largely, if not exclusively, to the ultra-violet content.

Speaking in general terms, the viability of the urediniospores appears to be low. Experiments showed that of the spores free from the surface of an infected leaf in the uredo stage, three days after collection, something less than 50 per cent are capable of germination. In ten days to two weeks, kept in a vial at room temperature, the germination is negligible. Cold storage and change of temperature rejuvenate and succeed in maintaining vitality in a gradually decreasing percentage of spores only for twenty-two days more.

From this it must follow that in nature successful infection requires the deposition of the spores in vast numbers. This is done in artificial inoculation work in the laboratory. Since the carrying of sufficiently large numbers of spores to great distances by the wind is unlikely, though perhaps possible, emphasis is deflected from this possibility as an important method of long-distance spread of the disease. Moreover, if light may have a toxic effect on the spores, their effectiveness when carried in the

air would be considerably reduced and their efficiency as agents for long-distance infection thus still further lessened.

Owing to the lateness of the season, the experiment on the effect of ultra-violet light was performed, of necessity, with spores collected a considerable time previously, and not with continuously fresh material as would have been advisable. This was prejudicial to the results, inasmuch as the percentage germination of the checks was rather too low to be

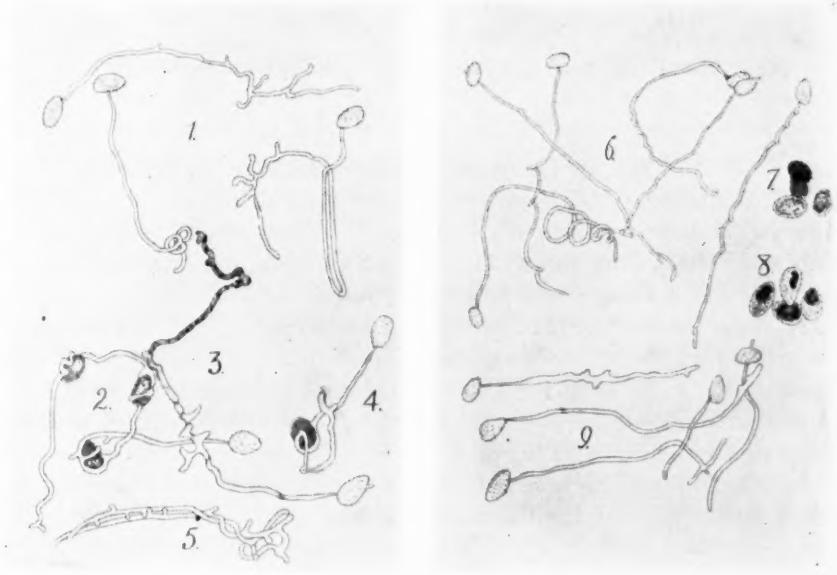


FIG. 1

1, Urediniospores germinated for twenty-four hours in distilled water after having been exposed for one and one-half hours to glass-filtered sunlight.

2–5, Urediniospores germinated for twenty-four hours in distilled water after having been exposed to glass-filtered sunlight for two and one-half hours. Note stimulation of the germ-tube where it encounters spores or another germ-tube.

6, Germination of urediniospores, in tap water, after twenty hours.

7, Normal urediniospores as they appear in a hanging-drop culture,

8, Old urediniospores in which the coloring matter has become segregated.

9, Germination of urediniospores, in distilled water, after twenty hours.

quite satisfactory. It appears to the writer that a repetition of these experiments with suitably fresh material should bear out strongly the results obtained, and this it is proposed to do next year. It was thought, however, that a brief summary might prove suggestive to others experimenting along the same line, and this note is published with that in view.

Acknowledgments are due to Mr. W. A. McCubbin, under whose direction these experiments were performed, for much helpful advice and assistance.

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NOTES ON PERIDERMIUMS FROM OHIO

NEED OF PATHOLOGICAL VIEWPOINT IN NURSERY INSPECTION

ROY G. PIERCE

On May 20, 1916, at the State Forester's nursery at Wooster, Ohio, Mr. D. C. Babcock and the writer collected a foliicolous rust on Austrian pine, *Pinus austriaca* Hoss. (F. P. 18197).[1] A rust similar in appearance had been collected by the writer on May 17, 1916, in Cincinnati at the Mt. Airy forest nursery and adjoining plantations on needles of Corsican pine, *Pinus laricio* Poir (F. P. 18210); Austrian pine (F. P. 18202); western yellow pine, *Pinus ponderosa* Dougl. (F. P. 18214); and pitch pine, *Pinus rigida* Mill. (F. P. 18207). The specimens of all these rusts from Cincinnati and Wooster were identified by Dr. George G. Hedgcock as *Peridermium carneum* (Bosc.) Seym. & Earle. The two hosts, Austrian pine and Corsican pine, it is believed, are new for this species of Peridermium. While 20 per cent of the Corsican, Austrian, and western yellow pines and 75 per cent of the pitch pines in the nursery and plantations in Cincinnati were infected by *Peridermium carneum*, no evidence could be found of this needle rust on red pine, *Pinus resinosa* Ait.; Scotch pine, *Pinus sylvestris* Linn.; or Japanese black pine, *Pinus thunbergii* Parl.

On September 20, 1916, the uredinial stage of the rust *Coleosporium vernoniae* B. and C. was found in abundance on *Vernonia maxima* Small, (F. P. 18283) in Cincinnati, in close proximity to the pines which in the previous May had been found with needles infected with *Peridermium carneum*. Identification of host and rust was made by Dr. G. G. Hedgcock.

The caulicolous rust, *Peridermium comptoniae* (Arthur) Orton and Adams, was also collected in two localities in Ohio in 1916, and is reported here, it is believed, for the first time from that state. At the Mt. Airy city nursery in Cincinnati three trees (F. P. 18199, 18700, 18204) in a lot of

[1] The numbers in parenthesis refer to specimens in the collections for study in the Office of Investigations in Forest Pathology.

nine thousand four-year old Austrian pine transplants were found by Mr. Edmund Secrest and the writer on May 17 bearing aecia of *Peridermium comptoniae*. On one of the specimens (F. P. 18199) *Peridermium carneum* was also found with aecia.

On May 19, the nurserymen at the State Forester's nursery at Wooster found a rust on the stem of a small Austrian pine in the transplant bed. On the following day Mr. Secrest, Mr. Babcock, and the writer found six additional trees in the same lot of four year old Austrian pine at this nursery bearing aecia of a rust on the pine stems. Specimens of these stem rusts on Austrian pine from Cincinnati and Wooster were identified by Dr. Perley Spaulding as *Peridermium comptoniae*. Both of the lots of four year old Austrian pine at Wooster and Cincinnati in the nurseries were received as two year old seedlings from a large forest tree nursery near New Haven, Connecticut. Since the infection was only on the first two years' growth, the trees were, without doubt, diseased at the time they were shipped from Connecticut.

Shafroth[2] shows that the sweet fern, *Comptonia peregrina* (L.) Coult. the alternate host for *Peridermium comptoniae*, has been found in seven counties in the northern half of Ohio. This range does not correspond with the natural range in Ohio of *Pinus virginiana* and *Pinus rigida*. The distribution of this infected stock of Austrian pine from Connecticut to Wooster and Cincinnati, Ohio, is not, therefore, so important as it might be if made to other states where both hosts of the sweet fern rust are abundant. The discovery of the sweet fern rust in nursery shipments of pine from Connecticut to Ohio directs attention to the need of better nursery inspection not only of the plants in the nursery itself but of the surroundings of the nursery from a pathological point of view.

Spaulding[3] called attention in 1914 to the advisability of nurserymen adopting measures for eradication of alternate hosts of the stem-inhabiting Peridermiums in the vicinity of their nurseries. This is already being considered by the State Nursery Inspectors in the case of the white pine blister rust, but not in the case of the other stem-girdling rusts, as far as the writer knows. A nursery can hardly be considered to be free of disease, and be given a clean bill of health or certificate of inspection, if the immediate vicinity of the nursery harbors diseased plants which can and do spread the disease to the nursery stock. The State Pathologists have a duty to perform in educating the nurserymen and the nursery inspectors

[2] Shafroth, John H. Catalogue of Ohio vascular plants. Ohio Biological Survey, Vol. I, Bulletin 2, March 1914.

[3] Spaulding, Perley. Notes on *Cronartium comptoniae* and *C. ribicola*. Phytopath., **4**: 409 D, 1917.

concerning the other forms of the stem-inhabiting pine rusts and the alternate hosts on which these forms are found.

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PUBLIC SCHOOL SURVEY FOR CURRANT RUST

W. A. MCCUBBIN

In endeavoring to ascertain the extent of the occurrence of the currant stage of the White Pine Blister Rust in Ontario in 1917 the usual method of sending out scouts was followed, but in order to save man power as much as possible an appeal was also made to the public schools to help in locating the disease. The results obtained by the latter method have been so satisfactory that it is thought worth while to record the main features of the scheme, since it may prove worthy of adoption in other localities, either in connection with this disease or in others where the observations to be made are of a similarly simple, outstanding nature.

In Ontario there are about 6000 public schools with nearly 500,000 pupils in attendance. Of these there are about 200,000 of an age suitable to our purpose. Our plan was to have these pupils examine their own black currants. This species is so susceptible to the rust and is so universally grown in the province that there was little need to use the other varieties or gooseberries. A card with a colored illustration of the currant rust, and bearing simple instructions, was provided, and the pupils were asked to look on the *under sides* of the leaves and if anything was found resembling the picture the leaves were to be taken to the teacher. The teacher was then to fill in a report form, noting the examinations made, and send this to us along with the suspected leaves collected. It was then a simple matter to examine the specimens submitted and tabulate and map the results.

It is apparent that there are two critical points in this scheme, first, securing the active interest of the teacher, and second, the use of a good illustration. If the teacher did not enter enthusiastically into the work little could be accomplished, hence we endeavored to arouse interest both by sending our own letter of explanation, and by the use of a form letter signed by the local county inspector requesting careful attention to our appeal. On the other hand a poor illustration is likely to confuse the most willing pupil and thus decrease possible results. Although the illustration used in our work was the best available at the time it was scarcely good enough for the purpose, and it is felt that the use of a more

faithful representation of a rusted leaf would have brought far greater success.

In the distribution of the colored cards, letters, etc. to the teachers, the county inspectors were asked to coöperate. An envelope containing the necessary literature for each school, together with a form letter from the inspector to the teachers, was sent to the inspector for each school in his district, and he was asked to sign the form letters, enclose them in the envelopes, and mail one to each of his schools.

Each of these envelopes thus sent contained, (1) the inspector's letter to the teacher, (2) our letter to the teacher, (3) a sheet of instructions regarding the teacher's appeal to the pupils and the return of reports, (4) ten to twenty illustrated cards for distribution, (5) a report sheet upon which the teacher was asked to enter the names of children who looked for the rust, and whether or not it was found, and (6) an addressed envelope for the returns. The text of the two letters and the sheet of instructions is given herewith.

INSPECTOR'S LETTER TO THE TEACHER

Dear Sir or Madam,—

In accordance with the request of the Minister of Education, I am sending you enclosed prints and instructions sent out by the Provincial Forestry Branch asking the children of your school to help them in obtaining information regarding the dangerous disease known as the White Pine Blister Rust.

Since this disease is a serious menace to our Canadian forests, I hope that you will not fail to give this request the fullest attention.

Yours very truly,

(Signed).....

Inspector.

OUR LETTER TO THE TEACHER

Forestry Branch, Parliament Buildings,
Toronto, September 22nd, 1917.

Dear Teacher,—

In our work in the control of the White Pine Blister Rust it is very important that we find out just how far the disease is spread in the province. While this disease injures White Pine most seriously it also lives during the summer on currants and gooseberries, where it appears as an orange-colored rust on the under sides of the leaves. In finding the disease in any locality we therefore look for it on the currants. Owing to war conditions we are unable to get enough inspectors to cover the province thoroughly, and we are forced to appeal to the school children to help us. We know that the boys and girls can find the disease on their currants at home just as easily as our inspectors could, since the rust is so readily seen on the leaves.

We would ask you to help in this work by getting all the pupils to examine their currant leaves, and if you or your friends can examine and report on some also, we would feel greatly obliged.

Please read carefully the sheet of instructions, distribute the cards to the children, and make returns on the form provided as soon as possible.

Your assistance in this work will be most gratefully received, and will help most materially in our efforts to save our Canadian forests from a deadly enemy.

Yours very truly,

(Signed) .....

Provincial Forester.

INSTRUCTIONS TO THE TEACHER

1. Give the pupils a short talk explaining what they are asked to do viz,—
   Look on the *under sides* of the leaves of all their currant and gooseberry bushes, and if they find anything that looks like the rust shown in the picture, bring some of the leaves to you.
   Look most carefully on black currants.
   Bring several leaves of anything found.
   The rust is of a bright orange color when fresh, but may fade or turn brown when old.
   Look on at least half the leaves on each bush.
2. Distribute the colored cards, one to each family as far as possible.
3. If you can examine and report on a few places yourself it will be of great advantage.
4. Fill in the report sheet with the names of all the pupils who have examined currants and gooseberries. State if they found rust or not.
5. Put report sheet in envelope supplied and with it put specimens of all rusted or doubtful leaves that are brought in.
6. Mail this report to us within ten days.

This appeal did not reach the schools in most cases until October 1. Under our conditions a much better result might be expected if the examinations were made not later than the middle of September, and preferably about September 1.

A short summary of the results is given below. With this is included for purposes of comparison, the data collected by our staff of scouts, equivalent to nine men for two months.

Number of counties in the province (northern unorganized districts not included)	43
Counties from which school reports were received	41
Counties failing to report	2
Counties in which currant rust was found in 1917	38
Counties in which schools found rust	34
Counties in which scouts found the rust	23
Counties where rust was found by schools but not by scouts	15
Counties where rust was found by scouts but not by schools	4
Total number of townships in the 43 counties	455
Townships from which school reports were received	322
Townships in which the school reports showed rust	120
Number of schools to which appeal was sent	4750
Total number of schools from which reports were received	1550

School reports unaccompanied by specimens	300
School reports accompanied by specimens	1250
School reports showing rust on specimens	240
Total number of children reported as having made examination of currants	9342
Average examinations made per school	7.4
Cost of scouting (estimated, 9 men, 2 months)	$2700.00
Cost of school campaign (estimated)	$500.00

It is to be noted in connection with the above summary that the figures given apply to the reports actually sent in where rust was suspected. There is every reason to think that in a very large number of cases no suspicious leaves were found and therefore no report was sent in, so that the actual number of pupils who examined for rust is very much larger than the figures given. It would have been of great advantage to have insisted on a report whether rust was found or not since the negative evidence, while not conclusive as to the absence of rust, would at least have indicated the thoroughness of the survey in any given locality.

In conclusion it may be said that every credit is due to the Ontario Department of Forestry, not only for adopting what was hitherto an untried method of disease survey, but for assuming the main burden of detailed work involved in bringing it to a successful conclusion.

DIVISION OF BOTANY, EXPERIMENTAL FARMS,
FIELD LABORATORY OF PLANT PATHOLOGY,
ST. CATHARINES, ONTARIO

PHYTOPATHOLOGICAL NOTES

Lightning injury to grape vines. The almost universal practice in eastern United States of training grape vines on wire trellises doubtless increases the possibility of injury from strokes of lightning. That injury from this source is not common, however, is certain, since the writer in several years of vineyard experience has only seen a few cases and in talking with growers has heard of only a few additional cases.

One unquestioned case of lightning injury is noted incidentally by the writer[1] in connection with the spread of *Cryptosporella viticola* Shear. In this case Dr. Gregory was present at the vineyard when the stroke occurred and later (July 16, 1912) found the vines of one row in a partially wilted condition. Usually not all of the leaves on any shoot were wilted. Examination of wilted shoots failed to show any injury except on some shoots a brown discoloration and the presence in abundance of pycnidia of *C. viticola.* Internally many of the internodes were found to have been rendered pithless. A pithless internode sometimes occurred between internodes showing no injury at all or between those showing only slight injury. There was no evident injury to the posts of the trellis. The vines were not killed. The wilted leaves fell off and axillary buds pushed forth so that in a few weeks the row could not be detected except on careful search.

In a vineyard at Fredonia, New York, the writer noticed a single long row (40 to 50 vines) that apparently had been replanted. Upon inquiry, the owner stated that lightning had struck in the row the previous season, shattering one post and killing every plant to the ground. The young plants were not set in but had come up from the roots of the injured vines. It is possible that a few plants were killed outright but not many.

From conversation with growers it appears that when lightning strikes in a vineyard all or most of the plants in a single row are likely to be injured, often being killed to the ground.

DONALD REDDICK.

Personals. Dr. L. R. Hesler, of the New York State College of Agriculture, is engaged temporarily in making a survey for truck and fruit diseases in the Gulf States, for the Plant Disease Survey Office of the Bureau of Plant Industry.

[1] New York Agr. Expt. Sta. Bul. 389:471. 1914.

Mr. Ellsworth Bethel of Colorado, well known for his work on the rusts, has been appointed a pathologist in the Office of Investigations in Forest Pathology. Miss Annie E. Rathbun and Miss Alma May Waterman, recently graduate students at Brown University, have been appointed scientific assistants in the same office.

In connection with the emergency work on the conservation of food products through the prevention of plant diseases, the Office of Cotton, Truck, and Forage Crop Disease Investigations of the Bureau of Plant Industry has made the following additions to its staff of pathological workers:

Dr. Ivan C. Jagger, formerly assistant professor of plant pathology in the University of Rochester, will act as pathological adviser on truck crop diseases for the southern states.

Dr. J. I. Lauritzen, of Cornell University, will take up extension work on the control of sweet potato diseases.

Dr. L. M. Massey, formerly instructor in plant pathology in Cornell University, has been assigned to extension work on the control of truck crop diseases in New Jersey, with headquarters at New Brunswick.

Mr. M. R. Ensign, of Brigham, Utah, recently a graduate student at Cornell University, will act as extension pathologist in the state of Arkansas, with headquarters at Fayetteville.

Mr. S. P. Doolittle, of Madison, Wis., will serve as extension pathologist in the state of Wisconsin in connection with his investigation of cucumber diseases at the University of Wisconsin.

Mr. F. C. Meier, recently a graduate student and instructor in botany at Harvard University, will take up pathological extension work in connection with the completion of his watermelon disease investigations.

Mr. D. G. Milbrath has been transferred from the Office of Crop Technology and will take up pathological extension work in California.

Mr. Glen B. Ramsey, formerly assistant pathologist of the Maine Agricultural Experiment Station, has been assigned to the position of extension pathologist in Maine, with headquarters at Orono.

Dr. Arthur J. Mix, recently an instructor in the department of botany of the University of Kansas, and Mr. L. M. McRae, of the Alabama Polytechnic Institute, will be assigned to pathological extension work.

Dr. V. B. Stewart, assistant professor of plant pathology in Cornell University, has accepted a temporary appointment for three months and will assist in the inspection of car load lots of perishable vegetables at terminal markets, in coöperation with the Bureau of Markets.

REVIEWS

Murrill's and Saccardo's Names of Polypores Compared. By William Alphonso Murrill. Published by the author. New York, 1918.

It is stated by the author that the object of this pamphlet is to harmonize the names used by Saccardo and Murrill for the species of North American polypores and boletes. Some herbaria use one system of nomenclature and some the other. By consulting this list, one can readily obtain the equivalent of any recognized name in either system. Collectors will also find the pamphlet useful as a check list.

H. A. EDSON.

APPENDIX

LINCOLN CONFERENCE

MINUTES OF WAR EMERGENCY CONFERENCE OF GREAT PLAINS PLANT PATHOLOGISTS, LINCOLN, MARCH 19–20, 1918

The meeting was called to order by Dr. E. C. Stakman, Commissioner for the Great Plains area. The following were present: from *Colorado*, H. E. Vasey; *Iowa*, I. E. Melhus, I. H. Vogel; *Kansas*, L. E. Melchers, A. J. Mix; *Minnesota*, E. M. Freeman, E. C. Stakman, A. F. Thiel, G. R. Bisby; *Missouri*, G. M. Reed; *Montana*, D. B. Swingle; *Nebraska*, E. M. Wilcox, R. J. Pool, Miss E. M. Anderson, Miss L. V. Walker, R. O. Cromwell, T. J. Fitzpatrick, H. P. Rigdon, H. W. Thurston, J. E. Weaver; *South Dakota*, A. N. Hume; for the *War Board*, H. H. Whetzel, E. C. Stakman, G. R. Lyman and F. D. Kern; from the *Department of Agriculture*, H. B. Humphrey, W. W. Gilbert and G. R. Lyman.

Dr. Freeman, President of the Phytopathological Society, pointed out the value of the movement toward correlation and concentration of effort, and the opportunities afforded the Great Plains pathologists, especially in work on cereal diseases. Dr. Wilcox, after a brief speech of welcome, spoke for informality of discussion and the importance of eradicating the isolation of Pathologists.

In response to Dr. Stakman's call for reports of progress, Commissioner Whetzel stated (in addition to the report already given, Science, N. S. **47**: 210–212, 1918) that the embargo on fungicides had been lifted, and that reasonable prices should obtain, regarding which information could be obtained from Dr. Coons of Michigan. Professor Whetzel has also prepared lists of emergency data for distribution to plant pathologists.

Research and the problems now demanding attention were discussed and the following actions taken:

Seed treatment for cereals. Dr. Stakman was elected leader. Seed disinfection experiments for the control of smuts are to be carried on by all the states represented. The effect of the different treatments on the yield, seed and smut, are especially to be considered.

Wheat diseases. Scab was reported as troublesome. Mr. Swingle of Montana was made leader. The effect of the scab fungus on crops other than wheat is to be given attention.

Black chaff was reported as perhaps not so serious as its prevalence might indicate. Prof. Melchers of Kansas was made leader.

Cereal diseases caused by imperfect fungi were referred to Dr. Humphrey as leader.

Stem rust was discussed as to the significance of biologic forms, and particularly as to its relation to the barberry; the necessity for publicity regarding the barberry and possible methods of insuring eradication were discussed. The following resolution was adopted:

THAT it is unanimously voted by this Conference, which is composed of representatives from the states comprising the Upper Mississippi Valley where the rust of wheat and other cereals is of utmost importance;

THAT the common barberry, *Berberis vulgaris* (both the green and purple varieties) is one of the chief factors in the rust of wheat and other cereals;

THAT the eradication of the common barberry throughout the Upper Missisippi Valley is unequivocally recommended, and especially at this time when every effort ought to be made to safeguard the production of a large cereal crop;

THAT, since the barberry is one of the chief factors in the rust of cereals, it is the firm and unanimous conviction of the members of this Conference that the eradication of the common barberry throughout this district would certainly decrease the amount of rust of cereals, that in all probability the eradication would considerably decrease the amount of rust and that it is easily within the realm of possibility that the eradication of common barberries may effectually control this rust which is such a serious menace to our greatest war-time crops;

THAT the attention of the public be especially called to the fact that the Japanese barberry (*Berberis Thunbergii*) is not only becoming more popular than the common barberry from horticultural standpoints, but that it has an especial advantage in that it does not harbor any stage of the rust of cereals.

Barley diseases: Stripe and smut diseases are to be investigated following the leadership of Dr. A. G. Johnson of Wisconsin.

Rye diseases: Ergot investigations are to be led by Dr. A. G. Johnson and smut work continued at the Minnesota station.

Oats diseases: Dr. Melhus of Iowa, was made leader to work in coöperation with other states.

Corn diseases: Root and ear rots are to be under the leadership of Dr. Melhus. Smut work assigned to Prof. Melchers of Kansas.

Potato diseases: Dr. Stakman was chosen to obtain data on the various Fusarium diseases, the information gathered to be presented to Dr. W. A. Orton for the assignment of work to the various stations. Other potato diseases were distributed as follows to the men in the Great Plains Region: *Blackleg*, Swingle, Wilcox, Melhus and Bisby; *Rhizoctonia*, Reed, Wilcox, and Vasey; *curly dwarf*, Melhus and United States Department of Agriculture (Greeley, Colorado Field Station); *scab*, Vasey, Reed (to coöperate with Lutman of Vermont); *tipburn*, Melchers, Melhus; *spraying*, Bisby, Wilcox; *leaf roll*, and related diseases, United States Department of Agriculture (Greeley, Colorado, Field Station), Horticultural Departments of Minnesota and Montana.

Sugar beet diseases: Prof. Vasey of Colorado was chosen leader.

Sorghum diseases: Kernel smut was reported important. Dr. Reed of Missouri was made leader.

Alfalfa and clover diseases were referred particularly to Mr. F. R. Jones, United States Department of Agriculture.

Bean diseases: Dr. M. F. Barrus, of the United States Department of Agriculture was asked to act in an advisory capacity and Drs. Reddick and Burkholder of Cornell were called on for assistance with mosaic and root rots.

Tomato diseases: Mr. Bisby was made leader for the Great Plains, to work with others in aiding Mr. F. J. Pritchard, United States Department of Agriculture, or Prof. H. W. Anderson, Illinois.

Fruit diseases: Prof. Whetzel gave a report on dusting, and its value. A discussion followed. It was decided that no action was required for this region, although perhaps Montana and Minnesota can carry on some work.

Flax diseases: Mr. C. S. Reddy, North Dakota, was chosen leader for this region.

The following motion was passed: "Moved, that it is the sense of this Confer-

ence that the War Emergency Board of American Plant Pathologists be requested to appoint a committee selected from the pathologists from the various parts of the country to act toward bringing about better coöperation between the United States Department of Agriculture and the various experiment stations with particular reference to the possibility of concentration of men and efforts on particular projects."

After consideration and discussion of the Plant Disease Survey, it was unanimously voted as the sense of the meeting:

THAT the Plant Disease Survey is of greatest fundamental importance, (a) in the direction of plant pathological programs in every state, (b) in the basis which it furnishes for correlation and coöperation between states and the Federal Government, (c) in the opportunities which it offers in the stimulation and standardization of methods of collection of disease loss statistics, and (d) especially in the development of greatest possible accuracy in the published estimate of crop losses:

THAT the excellent development and growth of the Plant Disease Survey has given gratifying evidence of the policy of the Department of Agriculture in the support of this survey;

THAT we urge upon the United States Department of Agriculture in the present crisis, when the Plant Disease Survey is of utmost emergency importance, the great necessity for not only a continuation of that support but also for the most liberal expansion and increase in that support which is possible at this time.

THAT we assure the United States Department of Agriculture that such increased support would in our opinion be of utmost importance and assistance in the pathological work of our several states.

Extension and teaching were discussed by Commissioner Whetzel. Dr. Freeman pointed out the value of mental tests, and of presenting to the students data as to the possibilities that may result from botanical training. Mr. W. W. Gilbert reported on the methods of getting data to the farmer through extension men in the various states, and the relation of such men to the states.

Regarding Man Power, Commissioner Kern reported, and the matters involved were discussed. Dr. Freeman was appointed as a member from this district to work with Drs. Coulter, Harper and Jones in considering the cases of men in relation to the draft. The usefulness of women in many lines was emphasized, and Dr. Kern was asked to list the women with plant pathological training.

Publicity of the right kind to the general public was urged by Commissioner Kern and methods discussed.

In behalf of the people at the college at Lincoln, the following motion was adopted:

THAT the conference express a hearty vote of thanks for the excellent entertainment, and that the secretary send a message of thanks to those concerned.

It was decided to hold an autumn meeting at the call of the chairman,

G. R. BISBY,
Secretary.

LITERATURE ON PLANT DISEASES[1]

COMPILED BY EUNICE R. OBERLY, LIBRARIAN, BUREAU OF PLANT INDUSTRY, AND FLORENCE P. SMITH, ASSISTANT

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All authors are urged to coöperate in making the list complete by sending their separates and by making corrections and additions, and especially by calling attention to meritorious articles published outside of regular journals. Reprints or correspondence should be addressed to Miss E. R. Oberly, Librarian, Bureau of Plant Industry, U. S. Dept. Agric., Washington, D. C.

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